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Demonstration Bulletin

Site Characterization Analysis Penetrometer System (SCAPS) LIF Sensor

U.S. Army, Navy, and Air Force (Tri-Services)

Technological Description: The Tri-Services Site Characterization Analysis Penetrometer System (SCAPS) was developed by the U.S. Army (U.S. Army Corps of Engineers, Waterways Experiment Station [WES] and the Army Environmental Center [AEC]), Navy (Naval Command, Control and Ocean Surveillance Center), and the Air Force (Armstrong Laboratory). The SCAPS program is developing a variety of downhole sensors. This demonstration examined the laser induced fluorescence (LIF) sensor used for petroleum detection. The U.S. Army holds a patent for the use of a sapphire window to transmit and return incident laser light and contaminant induced fluorescence. The LIF system used in the SCAPS system was modified from a design developed by the Navy to detect petroleum, oil, and lubricant fluorescence in seawater.

A complete cone penetrometer system consists of a truck, hydraulic rams and associated controllers, and the cone penetrometer itself (Figure 1). The weight of the truck provides a static reaction force, typically 20 tons, to advance the cone penetrometer. The hydraulic system, working against the static reaction on force, advances segments of threaded push rod 1 m long and 3.57 cm in diameter into the ground. The cone penetrometer, which is mounted on the end of the series of push rods, contains sensors that continuously log tip stress and sleeve friction. The data from these sensors is used to map subsurface stratigraphy. Conductivity or pore pressure sensors can be driven into the ground simultaneously.

The core of the SCAPS LIF system is the Nitrogen laser used to induce a fluorescence response in soils. The cone penetrometer unit is mounted on a specially engineered 20-ton truck designed with protected work spaces. The SCAPS cone penetrometer system has been modified to provide automatic grouting of the penetrometer hole during retraction of the cone penetrometer, and also decontaminates the push rods as they are retracted from the soil. The 20-ton cone penetrometer is capable of pushing standard push rods to depths of approximately 50 m. The LIF sensor is mounted slightly above the cone penetrometer sensor.

The main LIF sensor components are:

- Nitrogen (N_2) laser
- Fiber optic cable
- Monochromator to resolve the fluorescence emission as a function of wavelength
- Photodiode array (PDA) to detect the fluorescence emission spectrum and transduce the optical signal into an electrical signal
- OMA to interface between the optic system and the computer system
- Computer system

To operate the SCAPS LIF sensor, the cone penetrometer is positioned over a designated penetration point. The LIF sensor response is checked using a standard rhodamine solution held

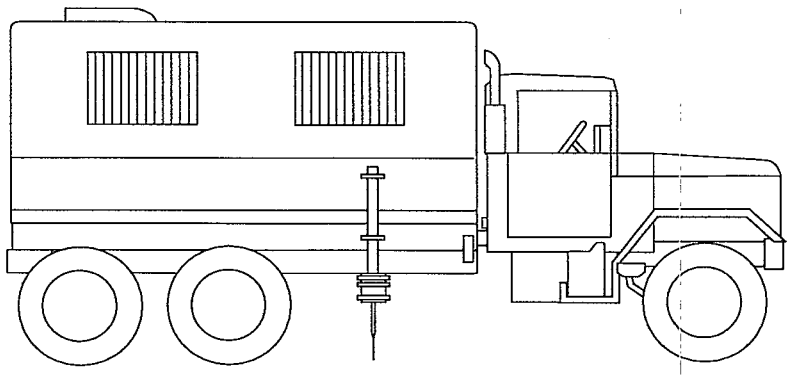

Figure 1. *Truck mounted cone penetrometer with SCAPS LIF sensor.*

against the sapphire window; sensor response is checked before and after each penetration. The cone penetrometer is then advanced into the soil.

The SCAPS LIF system is operated with a N_2 laser. The PDA accumulates the fluorescence emission response over 10 laser shots, and the PDA retrieves an emission spectrum of the soil fluorescence and returns this information to the OMA and computer system. The LIF sensor and stratigraphy data collection are interpreted and plotted against depth by the onboard computer system.

The vertical resolution of the SCAPS LIF system is 2 cm. The fluorescence intensity at peak emission wavelength for each stored spectrum is displayed along with the soil classification data. This intensity data can be used to identify waste types.

Waste Applicability: The Tri-Services SCAPS was designed to qualitatively identify classes and relative concentrations of petroleum, polynuclear aromatic hydrocarbons, and some volatile organic compound contamination in subsurface soil samples.

Demonstration Results: The technology field demonstration was held in EPA Region 7 during September 1994. An Innovative Technology Evaluation Report (ITER) describing the complete demonstration will be available in late 1995.

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For Further Information:

EPA Project Manager
J. Lary Jack
U.S. EPA
944 East Harmon
P.O. Box 93478
Las Vegas, NV 89193-3478
702-798-2373
Fax: 702-798-3146

United States
Environmental Protection Agency
National Risk Management Research Laboratory (G-72)
Cincinnati, OH 45268

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